

or thereabouts; but at whatever angle the bird rose, by a few flaps it attained a perfectly perpendicular position, as if suspended by its bill from the zenith, with its wings quite closed for a perceptible time; it then descended rapidly fifteen or twenty feet in a half-falling half-diving sort of way, but without turning a somersault, though the bird changed its position from head upwards to the reverse so suddenly as to cause it to appear to turn over. This play it would repeat three or four times in one place, and again further onwards; its mate was generally within fifty or a hundred yards, but sometimes much nearer.

I particularly noticed the call-notes; these were like *kè-wēē-kè-streer*, often repeated when the bird was playing; at other times quite a different call, like *itta-jee-ow*, repeated at short intervals.

I noticed that these birds now and again dashed off from their perches into the foliage of the tops of the trees, and secured some prey which they carried in their claws to a perch to eat.

XLIII.—*On the Structure of the Barbs, Barbules, and Barbicels of a Typical Pennaceous Feather.* By RICHARD S. WRAY, B.Sc. (London).

(Plate XII.)

HAVING occasion to illustrate the above structure in the Index Museum of the British Museum (Natural History), Professor Flower and myself came to the conclusion that the best way to do so would be by the preparation of a model, the making of which I undertook, and consequently I had to go thoroughly into the appearances presented by the parts specified. I find that although my observations correspond in all main particulars with what is already known, there are some points, especially in the relations of the proximal barbules to each other, which have not previously been fully appreciated. These points, and the fact that no good figure appears to exist giving at all a full idea of the completeness

and adaptive organization of these parts, have made me think that it might be worth while to publish the results of my work, founding my remarks upon the embodiment of it in the model which is in the Natural History Museum.

Figure 1 represents the main part of the model, and shows the inter-relation of the different parts.

Figures 2 and 4 represent part, modelled separately, showing the different details.

Figure 3 shows appearances which are indicated on the model (fig. 1), but cannot be shown in the drawing.

The model was made in gutta-percha, and modelled from nature, the feather selected being a greater wing-covert of a Goose.

Taking the parts in order, the stem of the feather gives off on either side the barbs, and they in turn the barbules, which are termed distal and proximal according as they originate from the side of the barb nearest the tip or the base of the feather. The barbules cross one another at an angle, and are especially modified to give consistency to the vanes. It is this adaptation the model was designed to show.

The proximal and distal barbules differ totally in form. The proximal barbules are (as shown in fig. 2) thin laminae with a thickened upper edge forming a small ledge or kind of flange (fig. 2, 1); the broad end is the one attached to the barb; the free half of the barbule is much narrower, and fines away to a mere filament. Where this thinning commences it is seen that the flange presents a broken appearance, there being three indentations giving a short "dog-tooth" edge (fig. 2, 2); beyond that the flange fines away. If a single barb be examined, the proximal barbules appear coming off at regular intervals, and at their proximal end appear to join on to an edge-piece running parallel to the barb. If now they are torn asunder with needles, this edge is seen to be formed by the attenuated halves of these barbules overlapping one another and being turned at a considerable angle upon the other half. The "dog-tooth" portion allows of this folding in the flange without any crumpling (fig. 3, α and β). This arrangement gives strength and elasticity to

the proximal half of every barb, since no one barbule bears at any time the whole of any strain placed directly upon it, but the strain is of necessity distributed.

The distal barbules present a totally different modification (fig. 4). Each one is a thin lamina bearing on its distal two-thirds barbicels, hooked in the centre of the barbule, but not at the end. The proximal third is a flat lamina about as broad as the proximal barbules, then it presents two or three tooth-like processes (fig. 4, 1) and becomes quite narrow, bearing five hooked barbicels, and then four or five unhooked ones, the end of the lamina being continued as a barbicel-like process. These all occur on its lower edge. On its upper edge there occur as many small tooth-like processes (fig. 4, 4) as there are unhooked barbicels, the two forming four or five pairs of processes.

If a section of a barb be examined showing the attachment of the barbules, the proximal barbules are seen to be attached somewhat lower down than the distal; and the proximal barbules slope gently downwards from their attachment, while the distal slope gently upward (*cf.* fig. 1). The distal barbules overlap the proximal, the overlapping being confined to the part beyond the teeth (1. fig. 4), the ends of the unhooked barbicels lying over the upper edge of the barb often. The hooklets (*hamuli*) catch the flange of the proximal barbules, and, being regularly arranged, each hooklet has a grip on a separate barbule; each distal barbule, therefore, is connected with five proximal ones, and as each of these is intimately connected with its fellows by the overlapping previously described, the whole forms a most complete adaptation of structure to function (*cf.* figs. 1 and 4).

The methods adopted in procuring data for the making of the model were as follows:—

- (1) A feather was soaked in turpentine, and bits of the vane were cut out and mounted in Canada balsam, showing the upper and lower surfaces.
- (2) Separate barbs were taken and mounted, the barbules on some being teased out with needles, on others the

Fig. 2

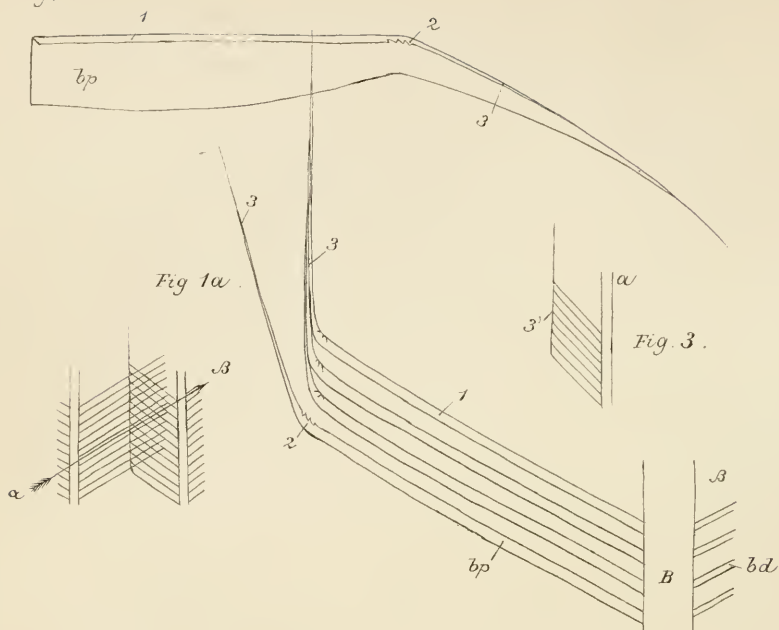


Fig. 4.

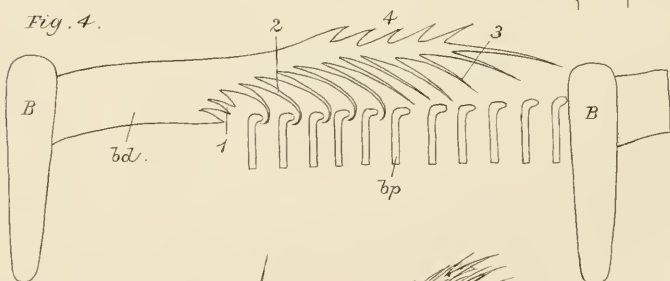
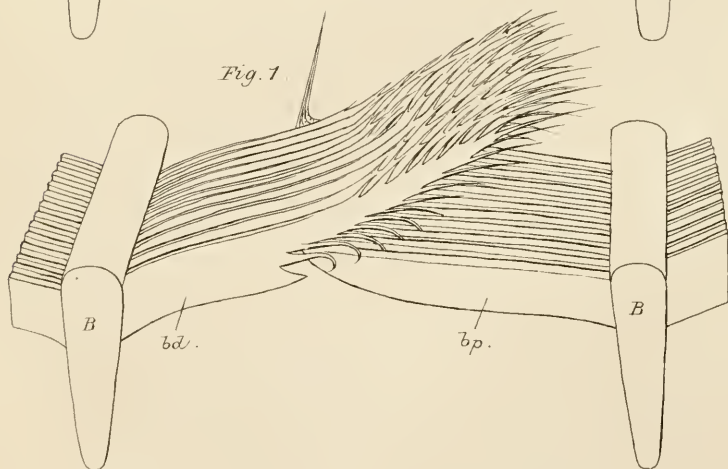


Fig. 1



barbules were cut off by placing a sharp razor on the sides of the barb and pressing gently on the slide, when sufficient perfect barbules of each kind were obtained for examination.

- (3) Portions of the vane were carefully embedded in paraffin, and sections cut and mounted by the kreosote-shellac method, so that the parts were obtained in their relative, natural and undisturbed positions.
 - (a) Transversely : *i. e.*, at right angles to the long axis of the barb).
 - (b) Horizontally : *i. e.*, parallel to the surface of the vane.
 - (c) Oblique sections in directions parallel to the distal barbules (*cf.* fig. 1*a*, α to β). Some of these showed the barbs in oblique section, a distal barbule quite perfect, and sections of the proximal barbules. In these could be seen exactly how the hooklets cling to the flange (*cf.* fig. 4).

Drawings were then made of all the parts in every position from these working-drawings, and the model produced in gutta-percha.

EXPLANATION OF PLATE XII.

B, barb ; *bd*, distal barbule ; and *bp*, proximal barbule in all figures.

- Fig. 1. Perspective view of portions of two adjacent barbs looking from the main stem towards the edge of the feather.
- Fig. 1*a*. Diagram of surface view, α to β direction of oblique sections described in text.
- Fig. 2. A proximal barbule. 1, flange ; 2, "dog-tooth" part of flange ; 3, overlapping portion.
- Fig. 3. Diagrammatic view of a barb from above. α , slightly magnified ; β , more highly magnified ; 3', the apparent firm edge parallel to barb. *B* shows its composition, 1, 2, 3 as in fig. 2.
- Fig. 4. Oblique section in direction α to β (fig. 1*a*), showing the exact manner of the interlocking of the barbules. 1, tooth-like processes ; 2, hooked barbicels ; 3, unhooked barbicels ; 4, processes serial with 3. The proximal barbules, *bp*, are seen in oblique section.